Clouds
Formation & Types
Air Compression and Expansion

• Adiabatic Temperature Changes
  o When air is allowed to expand, it cools, and when it is compressed, it warms.

• Expansion and Cooling
  o Dry adiabatic rate is the rate of cooling or heating that applies only to unsaturated air.
  o Wet adiabatic rate is the rate of adiabatic temperature change in saturated air.
Cloud Formation by Adiabatic Cooling

-8°C
-3°C
2°C
12°C
22°C
32°C

Condensation level

Wet adiabatic rate (temperature of rising air drops at 5°C/1000 meters)

Dry adiabatic rate (temperature of rising air drops at 10°C/1000 meters)
Cloud Formation by Adiabatic Cooling

- Moist adiabatic lapse rate: 6 °C per 1000 m
- Dry adiabatic lapse rate: 9.8 °C per 1000 m

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Processes That Lift Air

• 4 mechanisms that can cause air to rise:
  o orographic lifting
  o frontal wedging
  o convergence
  o localized convective lifting
Processes That Lift Air

• Orographic lifting
  o occurs when mountains act as barriers to the flow of air, forcing the air to ascend.
  o The air cools adiabatically; clouds and precipitation may result.

• Frontal Wedging
  o A front is the boundary between two adjoining air masses having contrasting characteristics.
Orographic Lifting & Frontal Wedging
Processes That Lift Air

• Convergence
  o Convergence is when air flows together and rises.

• Localized Convective Lifting
  o Localized convective lifting occurs where unequal surface heating causes pockets of air to rise because of their buoyancy.
Convergence and Localized Convective Lifting
Stability

• Density Differences
  o Stable air tends to remain in its original position, while unstable air tends to rise.

• Stability Measurements
  o Air stability is determined by measuring the temperature of the atmosphere at various heights.
  o The rate of change of air temperature with height is called the environmental lapse rate.
Stability

• Degrees of Stability
  o A temperature inversion occurs in a layer of limited depth in the atmosphere where the temperature increases rather than decreases with height.

• Stability and Daily Weather
  o When stable air is forced above the Earth’s surface, the clouds that form are widespread and have little vertical thickness compared to their horizontal dimension.
Condensation

• For any form of condensation to occur, the air must be saturated.

• Types of Surfaces
  o Generally, there must be a surface for water vapor to condense on.
  o Condensation nuclei are tiny bits of particulate matter that serve as surfaces on which water vapor condenses when condensation occurs in the air.
Types of Clouds

- Clouds are classified on the basis of their **form** and **height**.
  - **Cirrus** (Cirrus = a curl of hair) are clouds that are high, white and thin.
  - **Cumulus** (Cumulus = a pile) are clouds that consist of rounded individual cloud masses.
  - **Stratus** (Stratus = a layer) are clouds best described as sheets or layers that cover much or all of the sky.
Types of Clouds

• High Clouds
  o **Cirrus** clouds are high, white, and thin.
  o **Cirrostratus** clouds are flat layers of clouds.
  o **Cirrocumulus** clouds consist of fluffy masses.
Sometimes, when the sun is just below the horizon, aligned ice crystals reflect light from their crystal faces. We see the cumulative effect of millions of reflections of this sunlight as a sun pillar.
Types of Clouds

• Middle Clouds
  o *Altocumulus* clouds are composed of rounded masses that differ from *cirrocumulus* clouds in that *altocumulus* clouds are larger and denser.
  o *Altostratus* clouds create a uniform white to gray sheet covering the sky with the sun or moon visible as a bright spot.
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Types of Clouds

• Low Clouds
  o **Stratus** clouds are best described as sheets or layers that cover much or all of the sky.
  o **Stratocumulus** clouds have a scalloped bottom that appears as long parallel rolls or broken rounded patches.
  o **Nimbostratus** clouds are the main precipitation makers.
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Types of Clouds

• Clouds of Vertical Development
  
  Some clouds do not fit into any one of the three height categories mentioned. Such clouds have their bases in the low height range but often extend upward into the middle or high altitudes.
Fog

- Fog is defined as a cloud with its base at or very near the ground.
- Fog Caused by Cooling
  - As the air cools, it becomes denser and drains into low areas such as river valleys, where thick fog accumulations may occur.
- Fog Caused by Evaporation
  - When cool air moves over warm water, enough moisture may evaporate from the water surface to produce saturation.